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(54) CONTROL VALVE FOR POSITIVE CRANKCASE VENTILATION SYSTEM

(71) We, FORD MOTOR COMPANY LIMITED, of 88 Regent Street, London, W.1, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an internal combustion engine having a ventilated crankcase and an intake manifold.

The crankcase, valve chamber and timing gear housing of an automotive internal combustion engine are generally vented in order to prevent condensation, acid formation, damage from corrosive fumes and sludge deposits. Nearly all engines produced in recent years have employed ventilation systems of the type comprising a hose or tube extending from the crankcase or valve chamber to the intake manifold or air cleaner. Such systems are commonly called positive crankcase ventilation systems. When a hose or tube to the intake manifold is used, a valve controls the air flow so as to restrict the circulation at idle operation and to open the system at higher engine speeds. The valve restriction or opening generally is a function of the pressure differential between the crankcase or valve chamber and the intake manifold. It is desirable to reduce air flow to the intake manifold during low engine speeds and during certain transient conditions to prevent excessive leaning of the combustible mixture which can result in engine stumble or stall if not otherwise compensated. An unrestricted ventilating air flow at low speeds can result also in erratic or inconsistent low speed fuel-air ratios.

This invention provides in an internal combustion engine having a ventilated crankcase and an intake manifold, passage means communicating the crankcase and the intake manifold, valve means providing a variable restriction within said passage means in response to intake manifold vacuum pressure, means to delay the response of said valve means upon a sudden decrease in intake manifold vacuum.

In the accompanying drawings:

Figure 1 of the drawings is a cross-sectional view of a positive crankcase ventilation valve constructed in accordance with this invention.

Figure 2 is a view with portions broken away taken along line 2—2 of Figure 1.

Figure 3 is a schematic view of the positive crankcase ventilation valve showing its connection with a typical V-8 internal combustion engine.

A typical V-8 internal combustion engine 11 is shown in Figure 3 of the drawings in which the flow of a positive crankcase ventilation system is represented schematically by a series of broken lines and arrows. The ventilating air is initially drawn from the air cleaner 12 through hose 13 to the interior of valve cover 14. The ventilating air is then drawn from the valve cover through ventilating passages within the engine block (not shown) to the crankcase 16 and the timing gear enclosure (not shown) and, finally, into the opposite valve cover 17. The ventilating air, along with the oil fumes that it has picked up, is then drawn from the interior of valve 17 through line 15 to the positive crankcase ventilation valve assembly 18 which regulates its flow rate. After having passed through the valve assembly, the air and fumes are drawin through line 20 into the intake manifold 19 through a fitting 21 positioned in the carburetor spacer 22. The ventilating air and the oil fumes drawn into the intake manifold are combined with the fuel-air mixtures from the carburetor and form a part of the combustible mixture transmitted to the individual engine cylinders (not shown).

The valve assembly 18 comprises a vacuum motor portion 23 and a flow control portion 24. The flow control portion includes a housing 26 having inlet and outlet fittings 27 and 28, respectively, an orifice

29 and a tapered metering plunger 31 received within the orifice axially movable into and out of the orifice to increase and decrease the effective orific opening.

The upper portion 23 of the valve assembly 18 defines a vacuum motor enclosure 32 divided into two variable volume compartments 33 and 34 by a rubber diaphragm 36. The lower side of the diaphragm or compartment 34 is subjected continuously to atmospheric pressure which enters the compartment through vent 37. The upper side of the diaphragm or compartment 33 is exposed to intake manifold vacuum. A line 38 is connected to fitting 39 on the upper end of the valve assembly and together with line 20 communicates the upper compartment 33 of the vacuum motor with the intake manifold 19.

Rod 41 interconnects the vacuum motor diaphragm 36 and the plunger 31 to transmit the motions of the diaphragm to the plunger and vary the effective opening or the restriction of orifice 29. Rod guide 42 maintains the radial position of the plunger rod and seal 43 separates the atmospheric pressure of the lower compartment 34 from the vacuum pressure of the ventilating air flow within housing 26. Compression spring 44 acts against the housing and the diaphragm fitting 46 to urge the rod 41 and plunger 31 downwardly into a less restricting position within orifice 29. The atmospheric pressure or the pressure differential acting on the diaphragm 36 opposes the force of the compression spring 44 to urge the plunger 31 toward a more restricting position.

A time delay check valve assembly 47 includes an enclosure 48 having upper and lower seating surfaces 49 and 51 with openings 52 and 53 formed within them forming part of the passage or communication means from the upper compartment 33 of the vacuum motor to the intake manifold 19. A movable element 54 received within the enclosure 48 has generally a crown shape. When the movable element is seated on the upper surface 49, the vacuum pressure is communicated between the fingers 56 of the crown and through openings 52 and 53 with relatively unrestricted flow. When the movable element 54 is seated on the lower surface 51 of the enclosure, the communication between the upper compartment of the vacuum motor and the intake manifold must pass through the restricting orifice 57 of the movable element 54. It may be seen that if the differential between the intake manifold vacuum pressure and atmospheric pressure decreases suddenly, then the flow into compartment 33 will seat the movable element 54 on lower surface 51 and the pressure differential between the upper compartment of the vacuum motor and the intake manifold will equalize itself over a predetermined period of time through the restricted orifice 57.

The basic function of the pressure differential responsive valve 18 within a positive crankcase ventilation system as shown in Figure 3 of the drawings, is to restrict the flow of ventilating air during low and idle engine speeds. Unrestricted flow of ventilating air during these engine speeds has a leaning or dilution effect on the combustible mixture resulting in stumble or stall and potentially erratic or inconsistent fuel-air ratios. Thus, when the engine is idling and the intake manifold is correspondingly high, the positive crankcase ventilation valve causes restricted flow through the lines 15 and 20 which reduces the dilution effect of the ventilating air entering the combustible mixture. As the engine speeds are increased and the air flow through the carburetor spacer and the intake manifold is correspondingly increased, the valve 18 decreases its restriction and permits full gas flow so as to achieve complete crankcase ventilation at speeds at which the dilution effect of the ventilation air and gases entering the combustible mixture is negligible. This invention includes a time delay means 47 within the valve assembly 18 so that when the intake manifold vacuum drops suddenly as a result of a rapid acceleration from a low engine speed the valve plunger 31 will not immediately allow full flow of crankcase ventilation air through orifice 29, but the increase to full flow will be gradual over the period of acceleration.

More particularly, sudden acceleration from a low speed decreases the intake manifold vacuum causing the movable check valve element 54 to seat on the lower surface 51 of the enclosure because the absolute air pressure within the upper compartment 33 of the vacuum motor becomes less than that in the intake manifold 19. The intake manifold 19 pressure and the upper compartment 33 pressure equalize over a period of time by air bleeding through the orifice 57 of the movable check valve element. It can be seen that the size of the orifice within the movable check valve element determines the period of time in which the pressures equalize and in which the plunger 31 reaches its minimum restriction position.

Control of the flow of crankcase ventilating air during accelerations from low speed as described above permits under certain circumstances, a reduction in other enrichment techniques or devices that can, in order to provide a rich enough mixture to prevent engine stumble, result in "dirty" exhaust emission characteristics.

WHAT WE CLAIM IS:—

1. In an internal combustion engine hav-

ing a ventilated crankcase and an intake manifold,

passage means communicating the crankcase and the intake manifold,

valve means providing a variable restriction within said passage means in response to intake manifold vacuum pressure,

means to delay the response of said valve means upon a sudden decrease in intake manifold vacuum.

2. The apparatus of Claim 1,

said third-mentioned means comprising pressure differential decay means.

3. The apparatus of Claim 2,

said valve means including a vacuum motor in communication with said intake manifold,

said pressure differential decay means restricting the communication between said vacuum motor in one flow direction and permitting relatively unrestricted communication between said vacuum motor in the opposite flow direction.

4. The apparatus of Claim 2,

said valve means including an orifice formed within said passage means and a tapered plunger movable within said orifice to vary the effective restriction thereof.

5. The apparatus of Claim 3,

said valve means including an orifice formed within said passage means and a tapered plunger movable within said orifice to vary the effective restriction thereof, and

means connecting the vacuum motor and the plunger for coordinated movement.

6. In an internal combustion engine having a ventilated crankcase and an intake manifold,

passage means communicating the crankcase and the intake manifold and permitting flow from the crankcase to the manifold,

valve means providing a variable restriction within said passage,

said valve means including a housing forming a portion of said passage means,

an orifice positioned within said housing,

tapered plunger means movable into and out of said orifice to variably restrict and regulate flow through said orifice,

a chamber sealed from said housing being in communication with the intake manifold,

a flexible diaphragm dividing said chamber into two separate variable volume compartments,

connecting means transmitting motion of said diaphragm to said plunger means,

a first of said compartments being vented to the atmosphere,

passage means communicating the second of said compartments with the intake manifold,

spring means urging said plunger into a minimum restriction position and said second compartment to maximum volume,

check valve means permitting relatively unrestricted collapse of said second compartment and closing of said first-mentioned valve means in response to an increase in in pressure differential between the intake manifold and the atmosphere,

said check valve means having a pressure decay means permitting a controlled and restricted expansion of said second compartment over a predetermined period in response to a decrease in pressure differential between the intake manifold and the atmosphere.

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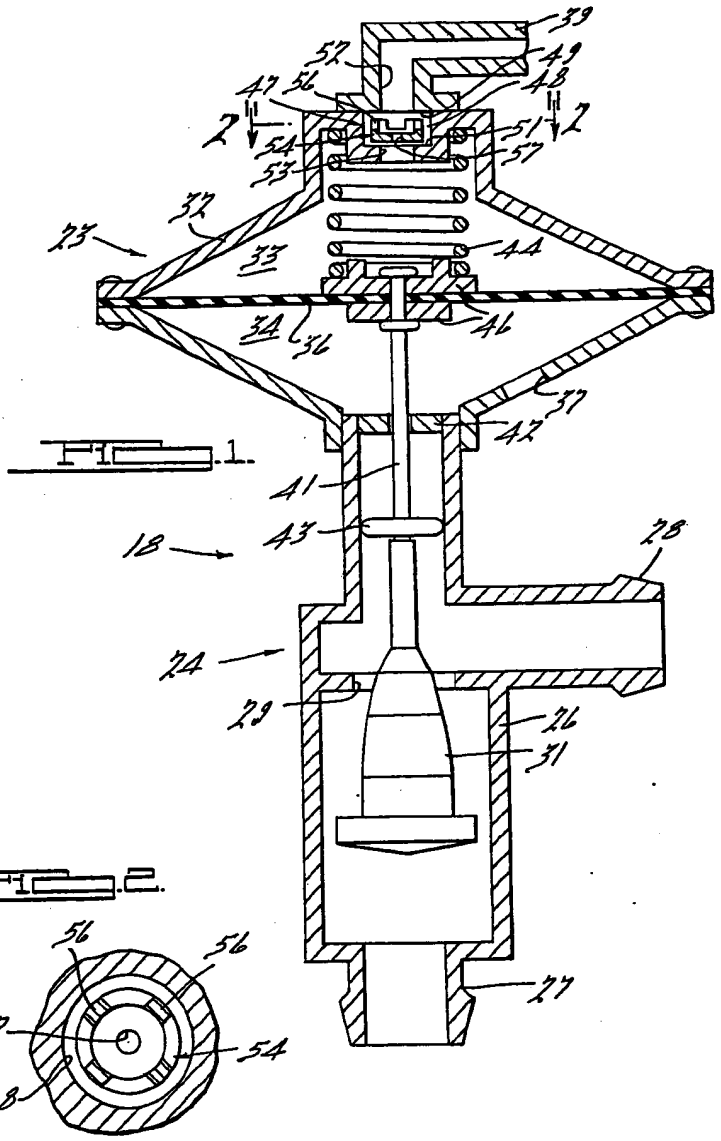

FIG. 1.

FIG. 2.

1358797 COMPLETE SPECIFICATION
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Sheet 2

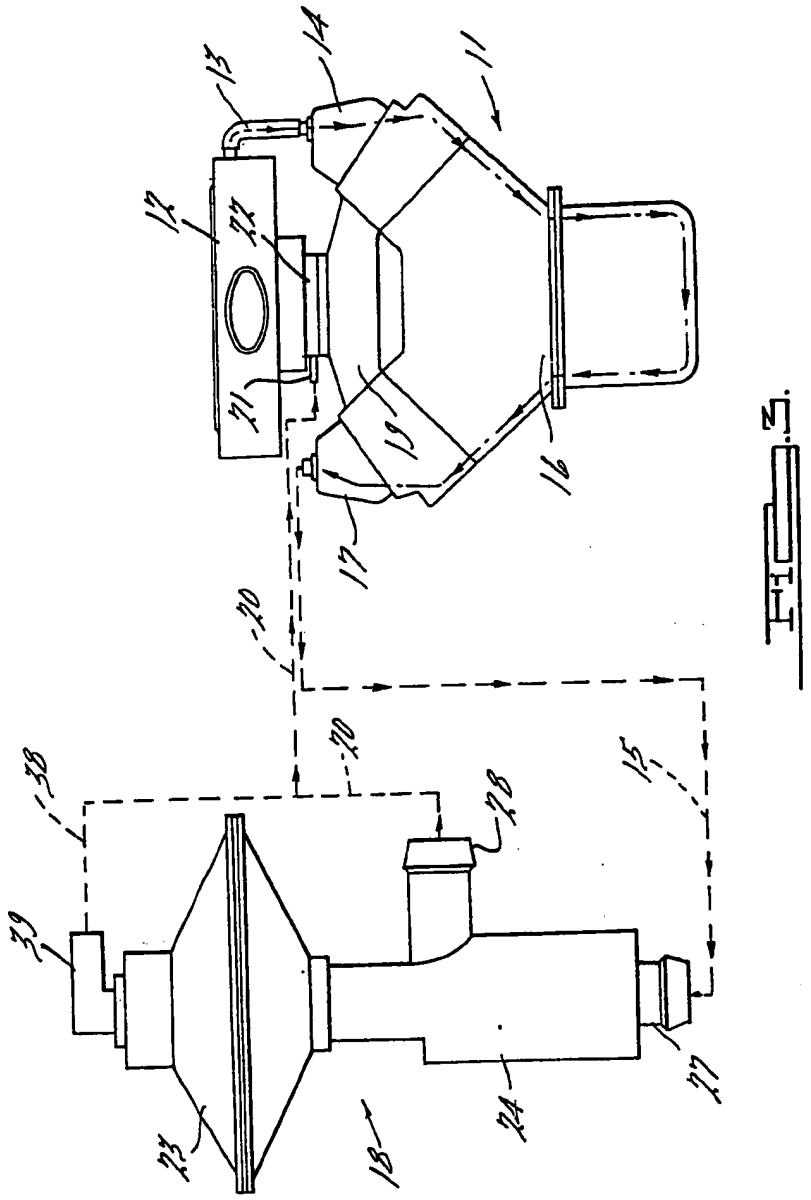

FIG. 1.